

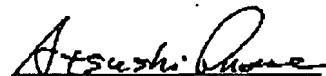
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of**Yuji TAKAHASHI et al.****Serial No. : 09/654,501****Filed: September 1, 2000****Group Art Unit: 2815****Examiner: Jerome Jackson****For: LIGHT EMITTING APPARATUS****Assistant Commissioner for Patents
Alexandria, VA 22313-1450****STATEMENT****Sir,**

I, Atsushi Inoue, hereby declare that I am conversant with both English and Japanese languages, and certify to best of my knowledge and belief that the attached are true and correct English translation of Japanese Patent Application No. H11-249350 filed on September 2, 1999.

**Atsushi Inoue****Date: June 14, 2007**

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Applicant(s): TOYODA GOSEI CO., LTD.

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[Title of the Invention] LIGHT-EMITTING APPARATUS

[Claims]

[Claim 1]

5 A light-emitting apparatus comprising:
a primary light source including a semiconductor
light-emitting device with an emission wavelength of from 380
nm to 500 nm; and
a secondary light source including a fluorescent material
10 composed of ZnS:Cu, Au, Al;
wherein said secondary light source emits light based
on light given from said primary light source so that light
of said secondary light source and the light of said primary
light source are mixed together to thereby generate light
15 different in luminescent color from the light emitted from said
primary light source.

[Claim 2]

A light-emitting apparatus according to claim 1, wherein
said fluorescent material is dispersed into a first layer
20 composed of a light-transmissible material,
a part of the light emitted from said primary light source
is transmitted through said first layer, and
the other part of the light emitted from said primary
light source is absorbed by said fluorescent material so that
25 said fluorescent material emits light and the light emitted

from said fluorescent material and the light emitted from said primary light source are mixed together to thereby generate light different in luminescent color from the light emitted from said primary light source.

5 [Claim 3]

A light-emitting apparatus according to claim 2, wherein said first layer comprises at least one member selected from the group consisting of epoxy resin, silicone resin, urea resin and glass.

10 [Claim 4]

A light-emitting apparatus according to claim 2 or 3, wherein said light-emitting device is fixed to a cup portion of a lead frame, and said first layer is formed so that said light-emitting device fixed to said cup portion is covered with 15 said first layer.

[Claim 5]

A light-emitting apparatus according to claim 4, wherein a sealing member is provided so that said light-emitting device, said first layer and a part of said lead frame are covered with 20 said sealing member.

[Claim 6]

A light-emitting apparatus according to claim 5, wherein said sealing member is composed of at least one member selected from the group consisting of epoxy resin, silicone resin, urea 25 resin and glass.

[Claim 7]:

A light-emitting apparatus according to claim 5 or 6, wherein said sealing member is shaped like a bullet.

[Claim 8]:

5 A light-emitting apparatus according to any of claims 2 to 7, wherein an amount of said fluorescent material changes continuously or stepwise as location of said fluorescent material in said first layer comes nearer said light-emitting device.

10 [Claim 9]:

A light-emitting apparatus according to any of claims 5 to 7, wherein said first layer and said sealing member are composed of the same material.

[Claim 10]:

15 A light-emitting apparatus according to claim 2, wherein said light-emitting device is of a chip type, and said first layer is formed so as to cover said light-emitting device.

[Detailed Description of the Invention]

20 [0001]

[Field of the Invention]

The present invention relates to a light-emitting apparatus. Particularly, it relates to a light-emitting apparatus which can emit white light as a whole by using a group 25 III nitride compound semiconductor light-emitting device and

a fluorescent material in combination.

[0002]

[Description of the Related Art]

A light-emitting apparatus which can emit white light
5 by using a blue light-emitting diode and a fluorescent material
of photoluminescence in combination has been disclosed in
Unexamined Japanese Patent Publication No. Hei. 10-242513. In
the light-emitting apparatus described in 10-242513, an
yttrium-aluminum-garnet fluorescent material activated by
10 cerium (Ce) to absorb light emitted from the blue light-emitting
diode and emit yellow light is used as the fluorescent material
so that the blue light emitted from the light-emitting diode
and the yellow light emitted from the fluorescent material are
mixed together to thereby generate white light.

15 [0003]

[Means for Solving the Problems]

The inventors of the present invention have eagerly
investigated various combinations of light-emitting devices
and fluorescent materials to provide a novel configuration of
20 a light-emitting apparatus which can emit white light.

As a result, it has been found that there is a ZnS
fluorescent material which exhibits an absorption spectrum to
light emitted from a light-emitting device and which emits light
when excited by the light emitted from the light-emitting device
25 so that the light emitted from the fluorescent material and

the light emitted from the light-emitting device are mixed together to thereby generate white light.

The present invention is a fruit of the aforementioned investigation. The configuration according to the present
5 invention is as follows.

There is provided a light-emitting apparatus comprising: a primary light source including a semiconductor light-emitting device with an emission wavelength of from 380 nm to 500 nm; and a secondary light source including a fluorescent material
10 composed of ZnS:Cu, Au, Al; wherein the secondary light source emits light on the basis of light given from the primary light source so that light of the secondary light source and the light of the primary light source are mixed together to thereby generate light different in luminescent color from the light
15 emitted from the primary light source.

[0004]

According to the aforementioned configuration, the fluorescent material emits light different in wavelength from light emitted from the primary light source when excited by
20 the light emitted from the primary light source. Hence, the light emitted from the secondary light source including the fluorescent material and the light emitted from the primary light source are mixed together, so that light different in luminescent color from the light emitted from the primary light
25 source is taken out. Because a fluorescent material excited

efficiently by light with an emission wavelength of from 380 nm to 500 nm to thereby emit light is used as the fluorescent material, a light-emitting apparatus of high luminance and high efficiency is obtained.

5 [0005]

[Embodiments of the Invention]

A material for forming a semiconductor light-emitting device constituting a primary light source is not particularly limited but, for example, a material with an emission wavelength of from 380 nm to 500 nm is used. Preferably, a material with an emission wavelength of from 420 nm to 490 nm is used. More preferably, a material with an emission wavelength of from 450 nm to 475 nm is used.

A group III nitride compound semiconductor is preferably used as the semiconductor light-emitting device. The "group III nitride compound semiconductor light-emitting device" means a semiconductor light-emitting device having a group III nitride compound semiconductor layer. The group III nitride compound semiconductor is represented by the general formula $Al_xGa_xIn_{1-x-y}N$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$, $0 \leq x+y \leq 1$), which includes so-called binary compounds such as AlN, GaN and InN, and so-called ternary compounds such as $Al_xGa_{1-x}N$, $Al_xIn_{1-x}N$ and $Ga_xIn_{1-x}N$ ($0 \leq x \leq 1$ in above). The group III elements may be partially replaced by boron (B), thallium (Tl). The nitrogen (N) may be partially replaced by phosphorus (P), arsenic (As),

antimony (Sb), bismuth (Bi). A device function portion of the light-emitting device is preferably constituted by a binary or ternary group III nitride compound semiconductor described above.

5 The group III nitride compound semiconductor may contain any optional dopant. Si, Ge, Se, Te, C may be used as n-type impurities. Mg, Zn, Be, Ca, Sr, Ba may be used as p-type impurities. Incidentally, since it is difficult to make a group III nitride compound semiconductor into a p-type semiconductor
10 with low resistance only by doping such p-type impurities, the group III nitride compound semiconductor may be subjected to electron beam irradiation, plasma irradiation or heat by a furnace after doped with p-type impurities.

The group III nitride compound semiconductor may be formed
15 by a metal organic chemical vapor deposition method (MOCVD method) or may be formed by any other known method such as a molecular beam epitaxy method (MBE method), a halide vapor phase epitaxy method (HVPE method), a sputtering method, an ion-plating method, an electron shower method.

20 A material of a substrate for growing the group III nitride compound semiconductor layer is not particularly limited so long as the group III nitride compound semiconductor layer can be grown on the substrate. Examples of the material of the substrate include sapphire, spinel, silicon, silicon carbide,
25 zinc oxide, gallium phosphide, gallium arsenide, magnesium

oxide, manganese oxide, group III nitride compound semiconductor single crystal. Especially, a sapphire substrate is preferably used. More especially, face a of a sapphire substrate is preferably used.

5 [0006]

A fluorescent material contained in a secondary light source is composed of a photo luminescence fluorescent material containing ZnS as a base and activated by Cu, Au or Al. Each of these fluorescent materials has an absorption spectrum 10 to light in a wavelength range of from blue to green and emits light with a wavelength longer than the excitation wavelength.

The secondary light source including the fluorescent material is provided in a position to be irradiated with light emitted from the primary light source. The secondary light 15 source emits light when excited by the light emitted from the primary light source. The light emitted from the secondary light source and the light emitted from the primary light source are mixed together so that light of a color different from the color of the primary light source is generated as a whole. If 20 a light-emitting device with a different emission wavelength is used, the luminescent color to be obtained can be changed. If the composition of the fluorescent material is changed, the luminescent color can be also changed.

[0007]

25 The use of the ZnS fluorescent material has the following

advantage compared with the case where a rare-earth element-activated fluorescent material is used as another typical fluorescent material. The ZnS fluorescent material does not need a large concentration of the activator compared 5 with the rare-earth element-activated fluorescent material. Hence, ZnS synthesized in advance is used so that dispersion of the activator into the ZnS lattice and growth of ZnS particles are performed by sintering. On the other hand, most of rare-earth element-activated fluorescent materials need a 10 relatively complex reaction in which generation of compounds, dispersion of the activator and growth of particles are performed by sintering. Moreover, the sintering temperature for the ZnS fluorescent material is generally lower. Thus, the use of the ZnS fluorescent material is advantageous in terms of synthesis 15 of the fluorescent material.

[0008]

In use, the fluorescent material is dispersed into a layer composed of a light-transmissible material. Examples of the light-transmissible material to be used are epoxy resin, 20 silicone resin, urea resin, glass. It is a matter of course that one material selected from these materials may be used singly. Moreover, a plurality of materials selected optionally from these materials may be used in combination.

The concentration distribution of the fluorescent 25 material in the light-transmissible material can be changed

in accordance with the purpose of use, the working condition. That is, the amount of the fluorescent material is changed continuously or stepwise as the location of the fluorescent material comes nearer the light-emitting device. For example,
5 the concentration of the fluorescent material in a portion nearer the light-emitting device is made higher. In this case, the fluorescent material can be efficiently irradiated with light emitted from the light-emitting device. The fluorescent material is, however, easily affected by heat generated in the
10 light-emitting device, so that deterioration of the fluorescent material becomes a subject of discussion. When the concentration of the fluorescent material is contrariwise set to decrease as the location of the fluorescent material comes nearer the light-emitting device, deterioration of the
15 fluorescent material caused by heat generated in the light-emitting device is suppressed.

The layer composed of the light-transmissible material containing the fluorescent material is provided in a direction of light emission of the primary light source. The layer is
20 preferably formed so as to cover the light emission side of the primary light source. Another layer of a light-transmissible material or a space may be provided between the layer and the primary light source.

[0009]

25 As described above, the secondary light source is

constituted by a layer of a light-transmissible material, containing a specific fluorescent material dispersed into the layer. When light emitted from the primary light source passes through the layer, the light emitted from the primary light source and the light emitted from the secondary light source are mixed together automatically in the layer. The mode for mixing the light of the primary light source and the light of the secondary light source is, however, not limited to the above description. For example, the fluorescent material is disposed 10 in the form of islands in the surrounds of the primary light source. Light emitted from the primary light source may go between islands of the fluorescent material so that the light of the primary light source and light emitted from the fluorescent material can be mixed together in a sealing member.

15 In this case, the light of the primary light source is not transmitted through the islands of the fluorescent material. Alternatively, in the light-emitting apparatus, the fluorescent material may be disposed in a position out of the optical axis of the light emitted from the primary light source 20 and the light emitted from the fluorescent material is condensed in a direction of the optical axis by use of a reflection plate so that the light of the primary light source and the light of the fluorescent material as the secondary light source are mixed.

25 [0010]

The light-emitting apparatus according to the present invention may be applied to a light-emitting diode display device (hereinafter referred to as "LED display device"), which displays white with high density and high precision. In the 5 background-art full-color LED display device, respective LEDs for red, green and blue (RGB) were used in combination as one pixel so that white light emission was obtained by mixture of the colors of light emitted from the respective LEDs. That is, light emission from three LEDs was required for display 10 of white, so that the display region for white light was large compared with the display region for light emission of a single color such as green, red. Hence, white could not be displayed with precision so high as green.

There is a possibility that white light emission can be 15 achieved singly by the light-emitting apparatus according to the present invention. Hence, when the light-emitting apparatus according to the present invention is used in combination with respective RGB LEDs, white display can be obtained with density and precision as high as emission light 20 of green, red. Moreover, there is an advantage that white display can be adjusted by control of the lighting condition of one light-emitting device. Moreover, because white display is not obtained by mixture of the colors of the light emitted from respective RGB LEDs as in the background art, the visual 25 color can be prevented from changing in accordance with the

viewing angle and color irregularity can be reduced. In addition, when the light-emitting apparatus according to the present invention is used in combination with respective RGB LEDs, white display by mixture of RGB colors and white display by the light-emitting apparatus can be performed simultaneously so that improvement of light intensity and luminance in white display can be achieved.

[0011]

[Embodiment]

10 (Embodiment 1)

Fig. 1 is a view showing a light-emitting apparatus 1 as an embodiment according to a first aspect of the present invention. Fig. 2 is a sectional view showing a light-emitting device 10 used in the light-emitting apparatus 1.

15 Specifications of respective layers in the light-emitting device 10 are as follows..

Layer	Composition	Dopant	(Thickness)
p-type layer 15	p-GaN	Mg	(0.3 μm)
Light-emitting layer 14	Superlattice structure		
Quantum well layer	In _{0.15} Ga _{0.85} N		(3.5 nm)
Barrier layer	GaN		(3.5 nm)
The number of repetition of quantum well and barrier layers: 1 to 10			
n-type layer 13	n-GaN	Si	(4 μm)
Buffer layer 12	AlN		(10 nm)
Substrate 11	Sapphire		(300 μm)

[0012]

The buffer layer 12 is used for growing a high-quality

semiconductor layer and is formed on a surface of the substrate 11 by a known method such as an MOCVD method. Although this embodiment showed the case where AlN was used as a buffer layer, the material of the buffer layer is not limited thereto. For 5 example, the buffer layer may be composed of binary compounds such as GaN and InN. Generally, it may be composed of a group III nitride compound semiconductor represented by the formula Al_xGa_yN ($0 \leq x \leq 1$, $0 \leq y \leq 1$, $x+y=1$) (ternary compounds). Further, it may be composed of a group III nitride compound semiconductor 10 represented by the formula Al_aGa_bIn_{1-a-b}N ($0 \leq a \leq 1$, $0 \leq b \leq 1$, $a+b \leq 1$) (quaternary compounds).

Each of the semiconductor layers is formed by a known MOCVD method. In the growth method, an ammonia gas and group III element alkyl compound gases such as trimethylgallium (TMG), 15 trimethylaluminum (TMA) and trimethylindium (TMI) are supplied onto a substrate heated to a suitable temperature and are subjected to a thermal decomposition reaction to thereby make a desired crystal grown on the buffer layer 12. It is a matter of course that the method for forming the semiconductor layers 20 is not limited to the above description and that the semiconductor layers may be formed by a known MBE method.

The structure of the light-emitting layer 14 is not limited to the superlattice structure. The structure may be of a single or double hetero type or of a homo-junction type. Alternatively, 25 the light-emitting layer may be formed by use of an MIS junction

or a PIN junction.

[0013]

A layer of $\text{Al}_x\text{Ga}_y\text{In}_{1-x-y}\text{N}$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$, $x+y \leq 1$) doped with an acceptor such as magnesium and having a wide band gap may be interposed between the light-emitting layer 14 and the p-type layer 15. This is because electrons imported into the light-emitting layer 14 are prevented from diffusing into the p-type layer 15.

The p-type layer 15 may be of a double-layered structure with a p^- layer of low hole density on the light-emitting layer 14 side and a p^+ layer of high hole density on the p-type electrode 18 side.

[0014]

An n-type electrode 19 is constituted by two layers of Al and V. After the p-type layer 15 is formed, the p-type layer 15, the light-emitting layer 14 and the n-type layer 13 are partially removed by etching. The n-type electrode 19 is formed on the exposed portion of the n-type layer 13 by vapor deposition.

A transparent electrode 17 is composed of a thin film containing gold. The transparent electrode 17 is laminated on the p-type layer 15 so as to cover the substantially whole upper surface of the p-type layer 15. Also a p-type electrode 18 is composed of a material containing gold. The p-type electrode 18 is formed on the transparent electrode 17 by vapor deposition.

After the semiconductor layers and the electrodes are formed by the aforementioned process, the step of separating the laminate into chips is carried out.

[0015]

5 A reflection layer may be provided between the light-emitting layer 14 and the substrate 11 or on a surface of the substrate 11 on which no semiconductor layer is formed. When such a reflection layer is provided, light emitted from the light-emitting layer 14 toward the substrate can be 10 efficiently reflected toward a light extracting direction. As a result, improvement of light-emitting efficiency can be achieved. Figs. 3 and 4 show light-emitting devices 100 and 101, respectively, each of which has such a reflection layer. Incidentally, in the light-emitting devices 100 and 101, parts 15 the same as those in the light-emitting device 10 are referenced correspondingly.

In the light-emitting device 100, a reflection layer 25 is formed just under the light-emitting layer 14. In the light-emitting device 101, a reflection layer 26 is formed on 20 a surface of the substrate 11 on which no semiconductor layer is formed. The reflection layer 25 is composed of metal nitride. Preferably, at least one member selected from the group consisting of titanium nitride, zirconium nitride and tantalum nitride may be used optionally as the metal nitride. Like the 25 reflection layer 25, the reflection layer 26 can be composed

of metal nitride. Alternatively, the reflection layer 26 may be composed of a single metal such as Al, In, Cu, Ag, Pt, Ir, Pd, Rh, W, Mo, Ti, Ni, or may be composed of an alloy containing a plurality of metals selected optionally from the 5 aforementioned metals.

[0016]

The light-emitting device 10 is mounted onto a cup portion 33 of a lead frame 30 through an adhesive agent 20. The adhesive agent 20 is prepared as a silver paste which contains an epoxy 10 resin, and silver as a filler mixed in the epoxy resin. Use of such a silver paste is suitable for improving radiation of heat from the light-emitting device 10.

[0017]

The cup portion 33 is filled with an epoxy resin 15 (hereinafter referred to as "fluorescent material resin") 35 containing a fluorescent material 36 dispersed therein uniformly. After wire bonding which will be described later, the cup portion 33 may be filled with the epoxy resin containing the fluorescent material 36. Alternatively, before the 20 light-emitting device 10 is mounted onto the cup portion 33, a layer containing the fluorescent material 36 may be formed on a surface of the light-emitting device 10. For example, the light-emitting device 10 may be dipped into the epoxy resin containing the fluorescent material 36 so that a fluorescent 25 material resin layer is formed on a surface of the light-emitting

device 10. Then, the light-emitting device 10 is mounted onto the cup portion 33 by use of the silver paste. Besides dipping, sputtering, coating, painting, may be used as a method for forming the fluorescent material resin layer.

5 In this embodiment, ZnS:Cu, Au, Al (named "P22-GY" with an emission peak of 535 nm and made by KASEI OPTONIX Ltd.) is used as the fluorescent material 36. Although this embodiment showed the case where an epoxy resin was used as a base material for dispersing the fluorescent material 36, the base material.
10 15 is not limited to the epoxy resin. For example, a transparent material such as silicone resin, urea resin, glass, may be used as the base material.

Although this embodiment showed the case where the fluorescent material 36 was dispersed into the fluorescent material resin 35 uniformly, the present invention may be applied also to the case where the concentration distribution of the fluorescent material 36 in the fluorescent material resin 35 has a gradient. For example, epoxy resins different in the concentration of the fluorescent material 36 may be used so
20 that a plurality of fluorescent material resin layers different in the concentration of the fluorescent material 36 are formed in the cup portion 33. Alternatively, the concentration of the fluorescent material 36 can be changed continuously.

The fluorescent material resin 35 may contain a diffuser
25 such as titanium oxide, titanium nitride, tantalum nitride,

aluminum oxide, silicon oxide, barium titanate.

If a sealing resin 50 which will be described later contains the fluorescent material 36, the fluorescent material resin 35 can be omitted. That is, in this case, the cup portion 5 33 is filled with the sealing resin 50 containing the fluorescent material 36. Also in this case, the concentration distribution of the fluorescent material 36 in the sealing resin 50 can have a gradient in the same manner as in the fluorescent material resin 35.

10 [0018]

The p-type electrode 18 and the n-type electrode 19 in the light-emitting device 10 are wire-bonded to lead frames 31 and 30 by wires 41 and 40 respectively.

Then, the light-emitting device 10, a part of the lead frame 30, a part of the lead frame 31 and the wires 40 and 41 are sealed by a sealing resin 50 composed of epoxy resin. The material of the sealing resin 50 is not particularly limited so long as the material is transparent. For example, besides the epoxy resin, silicon resin, urea resin or glass may be used 20 preferably. From the point of view of adhesion to the fluorescent material resin 35 and refractive index, the sealing resin 50 is preferably composed of the same material as that of the fluorescent material resin 35.

The sealing resin 50 is provided for the purpose of 25 protection of the device structure. When the shape of the

sealing resin 50 is changed in accordance with the purpose, a lens effect can be given to the sealing resin 50. For example, besides the bullet type shown in Fig. 1, a concave lens type, a convex lens type may be used as the molding type of the sealing.

5 resin 50. Further, the sealing resin 50 may be shaped like a circle, an ellipse or a rectangle viewed from the light extracting direction (upward in Fig. 1).

The fluorescent material 36 can be dispersed into the sealing resin 50 regardless of the case where the fluorescent 10 material resin 35 is omitted.

The sealing resin 50 may further contain a diffuser. The use of the diffuser can relax the directivity of light emitted from the light-emitting device 10. Examples of the diffuser to be used include titanium oxide, titanium nitride, tantalum 15 nitride, aluminum oxide, silicon oxide, barium titanate.

The sealing resin 50 may further contain a colorant. The colorant is used for preventing the fluorescent material from exhibiting a peculiar color when the light-emitting device 10 is switched on or off.

20 When light emitted from the light-emitting device 10 contains a lot of wavelengths in an ultraviolet light region, an ultraviolet light absorber may be contained in the sealing resin 50 so that improvement of the life is achieved.

Incidentally, one member or a plurality of members 25 optionally selected from the fluorescent material 36, the

diffuser, the colorant and the ultraviolet light absorber can be contained in the sealing resin 50.

[0019]

In addition to the light-emitting device 10, any other 5 light-emitting device may be used. A light-emitting device different in emission wavelength from the light-emitting device 10 can be used as the other light-emitting device. Preferably, the other light-emitting device is provided as a light-emitting device having an emission wavelength which does not 10 substantially excite the fluorescent material to emit light. The use of the other light-emitting device permits the light-emitting apparatus to emit also light of a color different from white.

Further, a plurality of light-emitting devices each 15 having the same configuration as the light-emitting device 10 may be used for achieving improvement of luminance.

[0020]

The light-emitting apparatus 1 according to this embodiment can be used as a light source for lighting a specific 20 member to be irradiated as well as the light-emitting apparatus 1 is used as a light source in a display device, a signal machine, as will be described later. For example, a fluorescent material is used as the member to be irradiated. For use of the 25 fluorescent material as the member to be irradiated, a fluorescent coating composition is applied onto the member to

be irradiated or is mixed with a material for forming the member to be irradiated. When the member to be irradiated is composed of fiber, fiber containing a fluorescent coating composition as an additional component is woven. When the member as a subject of irradiation is irradiated with light emitted from the light-emitting apparatus 1, the fluorescent material contained in the member as a subject of irradiation is particularly excited by light from the primary light source to emit peculiar light so that the surface design of the member as a subject of irradiation can be changed.

[0021]

(Embodiment 2)

In a light-emitting apparatus 2 as an embodiment according to the first aspect of the present invention, a light-emitting device 150 is used as a light-emitting device. Fig. 5 is an enlarged view of a light-emitting device 150 used in the light-emitting apparatus 2. Parts the same as those in the light-emitting apparatus 1 in Embodiment 1 are referenced correspondingly, and the description thereof will be omitted.

The light-emitting device 150 is prepared in such a manner that the electrodes 17, 18 and 19 are eliminated from the light-emitting device 10 shown in Fig. 1 and the light-emitting device 10 is fixed onto Zener diode 151 of a silicone substrate in the form of a flip chip. The p-type GaN contact layer 15 of the light-emitting device 10 is connected to a p-type region

of the Zener diode 151 through a metal electrode layer 153. The material of the metal electrode layer 153 is not particularly limited so long as ohmic contact can be obtained between the Zener diode 151 and the p-type GaN contact layer 13. For example, 5 a gold alloy, can be used as the material of the metal electrode layer 153. The n-type GaN contact layer 13 of the light-emitting device 10 is connected to an n-type region of the Zener diode 151 through a metal electrode layer 155. The material of the metal electrode layer 155 is not particularly limited so long 10 as ohmic contact can be obtained between the Zener diode 151 and the n-type GaN contact layer 13. For example, an aluminum alloy, can be used as the material of the metal electrode layer 155. The p-type region of the Zener diode 151 is connected to the lead frame 31 by the wire 41.

15 [0022]

(Embodiment 3)

Fig. 6 is a sectional view of a chip type LED 3 as an embodiment according to the first aspect of the present invention. Parts the same as those in the light-emitting apparatus 1 in Embodiment 1 are referenced correspondingly and the description 20 thereof will be omitted. The light-emitting device 10 is fixed into a box 60 by silver paste. The wires 40 and 41 connect the electrodes of the light-emitting device 10 to electrodes 61 and 62, respectively, provided in the box 60. A sealing 25 resin 65 is prepared by dispersing the fluorescent material

36 of ZnS:Cu, Au, Al (named "P22-GY" with an emission peak of 535 nm and made by KASEI OPTONIX Ltd.) uniformly into a transparent substrate of epoxy resin, silicon resin, urea resin. The light-emitting device 10 and the wires 40 and 41 are covered with the sealing resin 65. The chip type LED 3 emits white light as a whole on the basis of mixture of the light emitted from the fluorescent material 36 excited by light emitted from the light-emitting device 10 and the light directly extracted from the light-emitting device 10.

10 [0023]

(Embodiment 4)

Fig. 7 is a partly enlarged view of a display device 200 using the light-emitting apparatus 1 (hereinafter referred to as "W-LED") shown in Embodiment 1 in combination with RGB LEDs. 15 The display device 200 can be applied to a full-color LED display.

The display device 200 has an approximately rectangular display portion 201. A matrix of LED units 202 each composed of RGB LEDs and a W-LED is disposed in the display portion 201. The arrangement of the LEDs in each of the LED units 202 can 20 be selected optionally.

[0024]

A display method used in the display device 200 will be described below with reference to Fig. 8. Image data given from an input portion 210 is temporarily stored in an image 25 data storage means 220. A control portion 230 includes a pattern

selection circuit, a brightness modulation circuit and a light switching circuit which are not shown. The control portion 230 outputs a control signal for controlling the on/off state of each of the LED units 202 in accordance with the image data stored in the image data storage means 220. Each of the LED units 202 is lighted with brightness and color on the basis of the control signal, so that a specific shape is displayed with specific brightness and color on the display portion 201.

In the display device 200, each of the LED units 202 is composed of a combination of RGB LEDs and a W-LED. However, if LED units each composed of a W-LED alone are arranged in the form of a matrix to thereby form a display portion 201, it is possible to obtain a display device which can display any shape, with white (by switching on a W-LED) and black (by switching off a W-LED). Also in this case, the brightness of each of the LED units can be controlled in tone so that the LED units can be applied to a monochrome LED display.

{0025}

(Embodiment 5)

Fig. 9 is a view showing a vehicle signal machine 300 using chip type LEDs 3 described above. The signal machine 300 has a display portion 302. A matrix of chip type LEDs 3 is disposed in the display portion 302. In Fig. 9, the reference numeral 301 designates a box. The display portion 302 is covered with a transparent colored cover which is not shown. The on/off

state of each of the LEDs 3 is controlled by a control means. White light generated when the LED 3 is turned on is colored visibly by passing through the transparent colored cover. It is a matter of course that a transparent colorless cover may 5 be used for making the signal machine display white. Power supply to the LEDs 3 is achieved by parallel or series connection of the respective LEDs 3. When the LEDs are series-connected, the LEDs 3 may be divided into a plurality of groups so that power is supplied to each group. When, for example, such LED 10 groups are disposed concentrically in the display portion 302, the display portion 302 can be provided as a portion having the LEDs disposed circularly as a whole. Incidentally, control of the on/off state may be performed for each LED group.

[0026]

15 The use of such a matrix of chip type LEDs 3 to form a light source permits the light source to emit light with uniform brightness on the whole display portion. Hence, brightness irregularity caused by use of electric bulbs in the background art can be reduced. The control of the on/off state for each 20 LED group in the aforementioned manner permits the display portion to perform display partially different in brightness.

Incidentally, the method for arranging the chip type LEDs 3 and the density in arrangement thereof can be selected optionally in accordance with purposes.

25 [0027]

(Embodiment 6):

Figs. 10A and 10B show a linear light source 400 and a surface light source 500 using chip type LEDs 3 described above.

The linear light source 400 roughly has a chip type LED 3, a light guide 401, and a box 403. The light guide 401 is composed of epoxy resin. It is a matter of course that any other transparent resin, may be used as the light guide. The light guide 401 uniformly contains a diffuser not shown, so that uniform light emission can be made. Although this embodiment showed the case where a transparent light guide was used, the present invention may be applied also to the case where the light guide is colored so that the linear light source can be provided for emitting light of a specific color.

Alternatively, a suitable fluorescent material may be contained in the light guide so that the linear light source can be provided for emitting light of a specific color on the basis of the fluorescent function of the fluorescent material. For example, the linear light source 400 can be used as an indicator in any kind of meter.

20 [0028]

The surface light source 500 has a box 503, a plurality of chip type LEDs 3 linearly arranged in the box 503, and a planar light guide 501 attached to the box 503 in a direction of light emission of the LEDs 3. The light guide 501 is composed 25 of epoxy resin containing a diffuser not shown. Reflection

members may be disposed on the back of the light guide 501 and on a side in which the LEDs 3 are not disposed. The provision of such reflection members improves frontal light-emitting efficiency. Hence, for example, the surface light source can 5 be utilized as a light source having brightness sufficient to be adapted to a back-lighting unit of a liquid-crystal monitor used in a personal computer.

[0029]

(Embodiment 7)

10 Fig. 11 is a view showing a color conversion filter 600 using an LED 605. The color conversion filter 600 roughly has an LED 605, a color conversion sheet 610, and a light guide layer 603.

The LED 605 is configured in the same manner as in the 15 light-emitting apparatus 1 according to Embodiment 1 except that the cup portion 33 is also filled with the sealing resin 50 instead of the epoxy resin 35 containing the fluorescent material 36. Incidentally, the chip type LED may be used.

The color conversion sheet 610 has a fluorescent material 20 layer 601, and a transparent sheet 602 composed of transparent resin. The fluorescent material layer 601 is prepared by dispersion of a fluorescent material of ZnS:Cu, Au, Al (named "P22-GY" with an emission peak of 535 nm and made by KASEI OPTONIX Ltd.) into a transparent substrate of epoxy resin, silicon resin, 25 urea resin. In this embodiment, PET is used as the material

of the transparent sheet 602. The fluorescent material layer 601 is preferably formed to have a finely rough surface. This is because the fluorescent material layer 601 and glass, disposed on an upper surface of the fluorescent material layer 601 are fitted to each other well to thereby prevent light from blurring in the interface therebetween. Also a contact surface of the transparent sheet 602 and the light guide layer 603 is preferably provided as a finely rough surface. This is because the transparent sheet 602 is prevented from coming into close contact with the light guide layer 603 to thereby prevent light from blurring in the interface therebetween.

The light guide layer 603 is composed of epoxy resin. It is a matter of course that the light guide layer 603 may be composed of any other transparent resin such as silicon resin. A reflection layer 604 is formed on a lower surface of the light guide layer 603 so that light is prevented from leaking out from the lower surface of the light guide layer 603. The material of the reflection layer 604 is not particularly limited or the reflection layer 604 may be omitted.

Light emitted from the LED 605 is incident on a side surface of the light guide layer 603 and extracted from the fluorescent material layer 601 side. When the light passes through the fluorescent material layer 601, a part of the light emitted from the LED 605 excites the fluorescent material to emit light. The light emitted from the fluorescent material and the light

emitted from the LED 605 are mixed together so that white light as a whole is extracted.

In addition to the LED 605, any other LED different in emission wavelength from the LED 605 may be used as a different 5 light source. In this case, the color conversion filter can be provided as a filter which can emit light of various colors in accordance with the on/off control over the LEDs.

[0030]

(Embodiment 8)

10 Fig. 12 is a view showing a cap type light-emitting apparatus 700 as an embodiment according to the present invention. Parts the same as those in the light-emitting apparatus 1 according to Embodiment 1 are referenced correspondingly and the description thereof will be omitted.

15 The light-emitting apparatus 700 is configured in the same manner as in the light-emitting apparatus 1 except that the cup portion 33 is not filled with the resin containing the fluorescent material and that a fluorescent material layer 710 composed of epoxy resin containing a fluorescent material 36 20 is formed to cover the sealing resin 50.

Being transmitted through the fluorescent material layer 710, a part of light emitted from the light-emitting device 10 excites the fluorescent material 36 to emit light. The light emitted from the fluorescent material 36 and the light 25 transmitted through the fluorescent material layer 700 and

extracted directly from the light-emitting device 10 are mixed together, so that the light-emitting apparatus 700 emits white light as a whole. The fluorescent material layer 700 is formed so that the thickness of its upper portion 715 and the thickness 5 of its side portion 713 are different from each other. The upper portion of the fluorescent material layer 700 mainly in a light extracting direction is thickened so that the light-emitting apparatus 700 can emit light uniformly as a whole.

After the sealing resin 50 is formed, the fluorescent 10 material layer 710 is formed by molding, in the same manner as the sealing resin 50 so that the sealing resin 50 is covered with the fluorescent material layer 700. Alternatively, a resin containing the fluorescent material 36 and shaped like a cap may be prepared so that the resin can be applied onto 15 the sealing resin 50 so that a fluorescent material layer 700 is formed after formation of the sealing resin 50.

Besides the epoxy resin in this embodiment, a thermosetting resin such as urea resin, a thermoplastic resin such as polyethylene may be used as the material of the 20 fluorescent material layer 700.

The fluorescent material layer 700 may further contain a diffuser such as titanium oxide, titanium nitride, tantalum nitride, aluminum oxide, silicon oxide, barium titanate.

[0031]

25 The present invention is not limited to the mode for

carrying out the invention and the embodiment thereof at all, and includes various modifications which can be conceived easily by those skilled in the art, without departing from the scope of claim.

5 [Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a view showing a light-emitting apparatus 1 as an embodiment according to of the present invention.

[Fig. 2]

10 Fig. 2 is a schematic sectional view of a light-emitting device 10 used in the light-emitting apparatus 1.

[Fig. 3]

Fig. 3 is a schematic sectional view of another configuration of a light-emitting device 100 having a reflection 15 layer just under the light-emitting layer.

[Fig. 4]

Fig. 4 is a schematic sectional view of a light-emitting device 101 having a reflection layer on a surface of the substrate on which any semiconductor layer is not formed.

20 [Fig. 5]

Fig. 5 is a partly enlarged view of a light-emitting apparatus which uses a planer type Zener light-emitting device 150 as another embodiment according to the present invention.

[Fig. 6]

25 Fig. 6 is a view showing a chip type LED 3 as a further

embodiment according to the present invention.

[Fig. 7]

Fig. 7 is a partly enlarged view of a display device 200 as a further embodiment according to the present invention..

5 [Fig. 8]

Fig. 8 is a view showing circuit configuration of the display device 200.

[Fig. 9]

10 Fig. 9 is a view showing a signal machine 300 as a further embodiment according to the present invention.

[Fig. 10]

Figs. 10A and 10B are views showing a linear light source 400 and a surface light source 500 as a further embodiment according to the present invention.

15 [Fig. 11]

Fig. 11 is a view showing a color conversion filter 600 as a further embodiment according to the present invention;

[Fig. 12]

20 Fig. 12 is a view showing a cap type light-emitting apparatus 700 as a further embodiment according to the present invention.

[Description of Reference Numeral]

1 Light emitting device

3 Chip-type LED

25 10 Light emitting element

35 Fluorescent material resin
36 Fluorescent material resin
50 65 Sealing resin
200 Display device ..
5 202 Light emitting unit
300 Signal machine
400 Linear light source
500 Surface light source
401 501 Light guide
10 600 Color conversion filter
610 Color conversion sheet
700 Cap type LED
710 Fluorescent material layer

[Document Name] Abstract

[Abstract]

[Purpose]

To provide a novel configuration of a light-emitting
5 apparatus which can emit white light.

[Configuration]

A combination of a group III nitride compound
semiconductor and a fluorescent material composed of ZnS: Cu,
Au, Al is used. White light emission is obtained by mixing
10 light emitted by the group III nitride compound semiconductor
and light emitted by the fluorescent material due to light
irradiation from the group III nitride compound semiconductor.

[Selected Drawings] Fig. 1

整理番号=P 0 1 6 2

提出日 平成11年 9月 2日
特許平11-249350 頁: 1/ 12

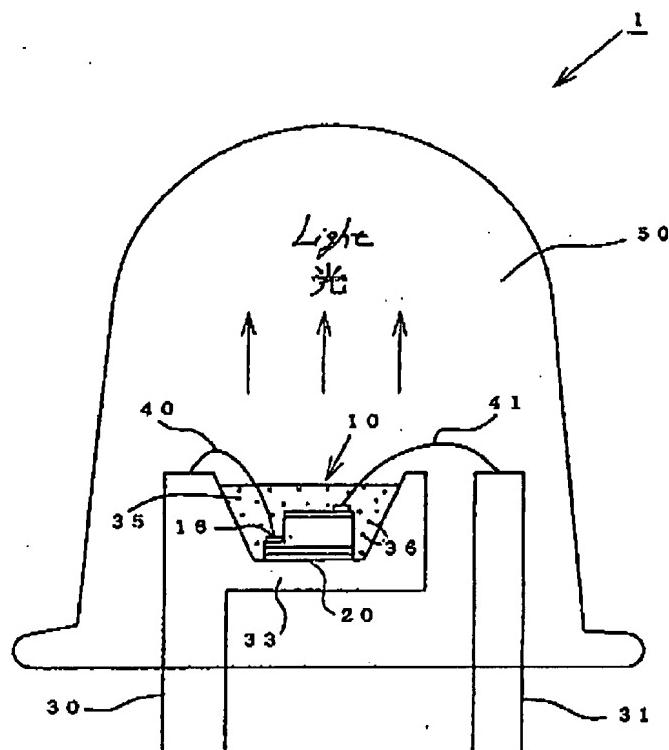
〔書類名〕

一図面

[Document Name] Drawings

〔図1〕

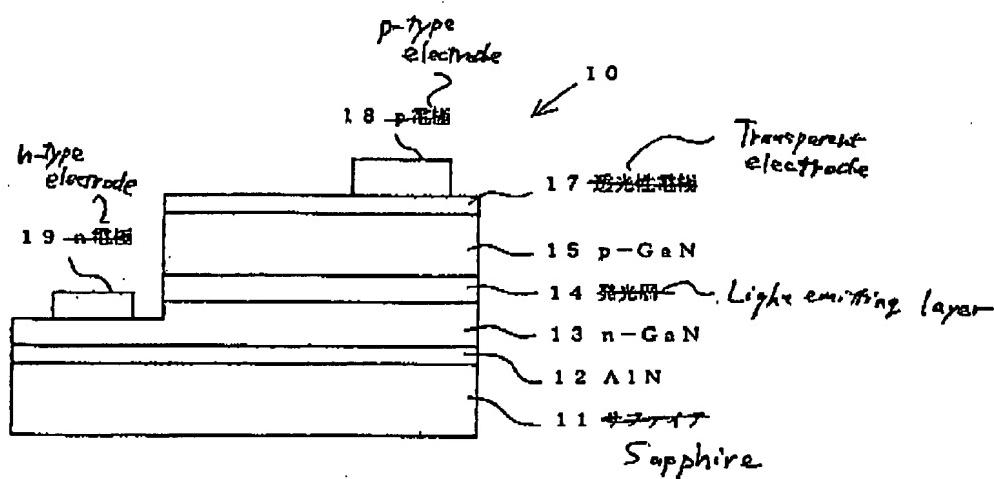
Fig. 1



整理番号=P0162提出日 平成11年 9月 2日
特願平11-249350 頁: 2/ 12

【図2】

Fig. 2

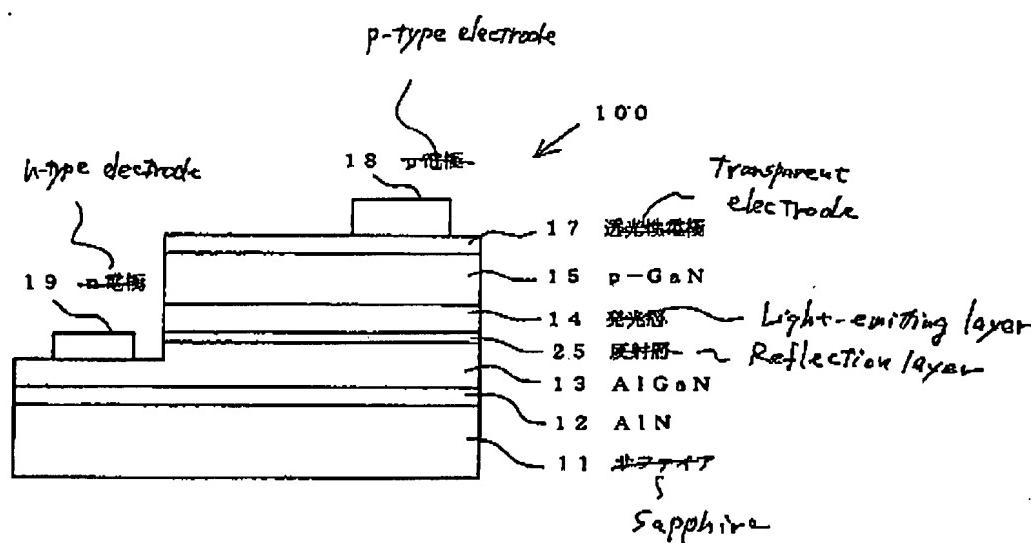


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特願平11-249350 頁: 3/ 12

【図3】

Fig.3

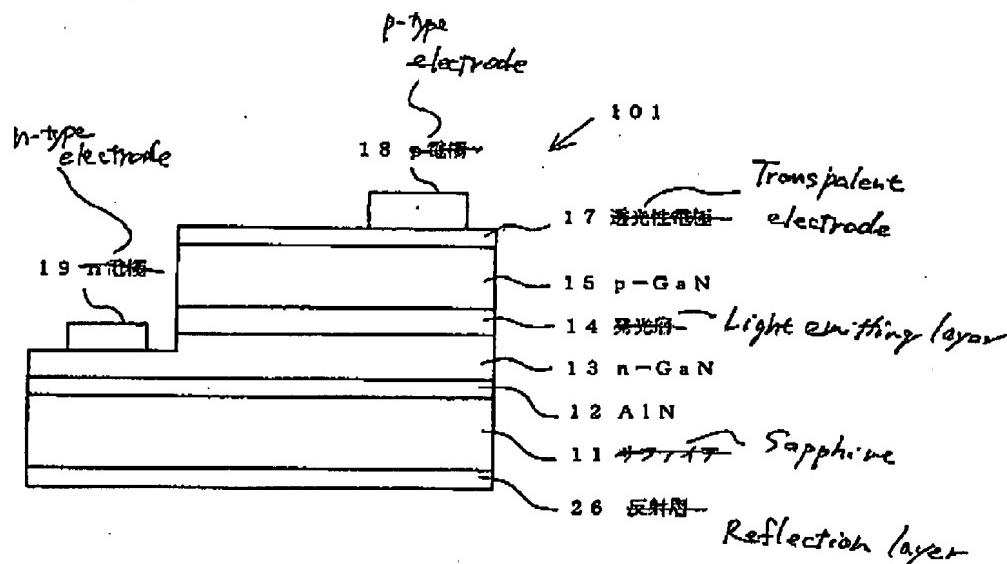


整理番号=P0162

提出日 平成11年 9月 2日
特願平11-249350 頁: 4/ 12

〔図4〕

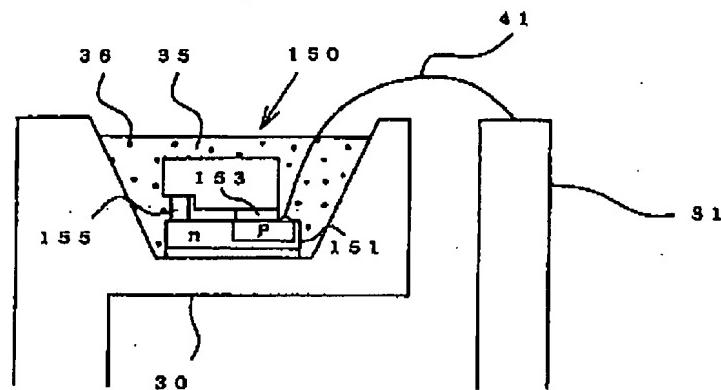
Fig. 4



整理番号=P 0 1 6 2提出日 平成11年 9月 2日
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[図-5]

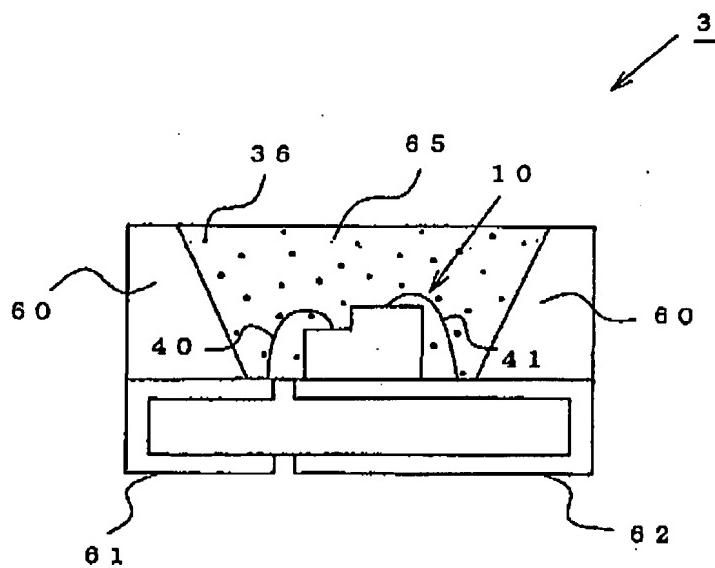
Fig. 5



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〔図6〕

Fig. 6

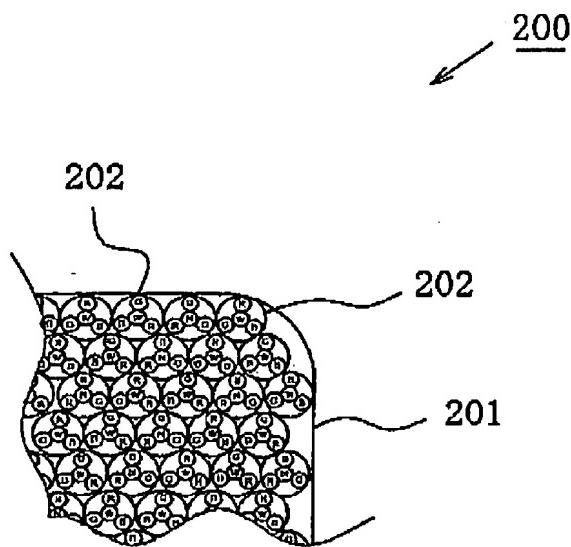


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十图7)

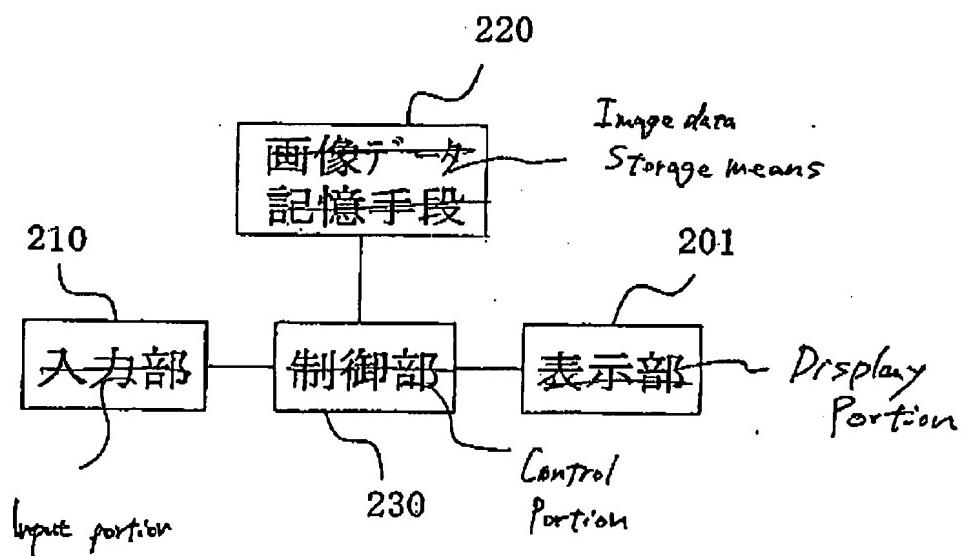
Fig. 7



整理番号=P 0 1 6 2提出日 平成11年 9月 2日
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{図8}

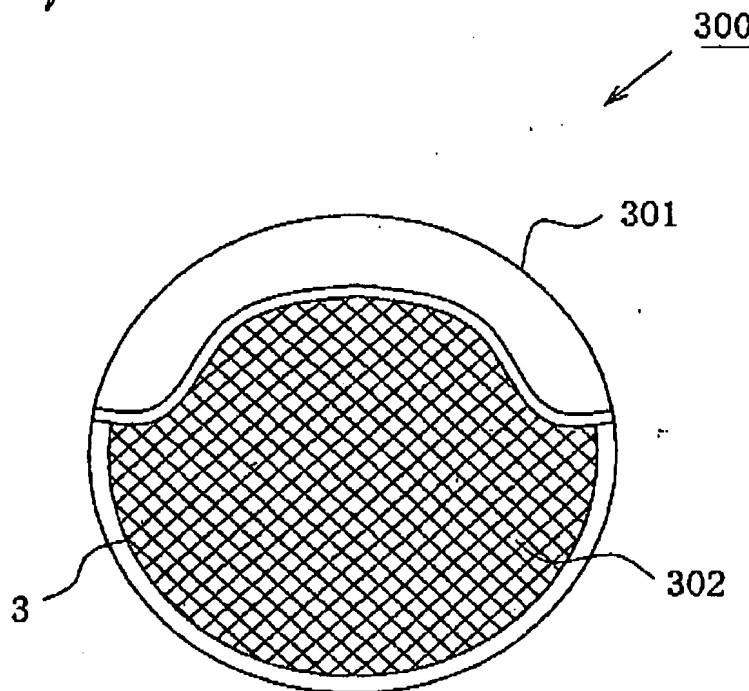
Fig. 8



整理番号=P.0162提出日 平成11年 9月 2日
特願平11-249350 頁: 9/ 12

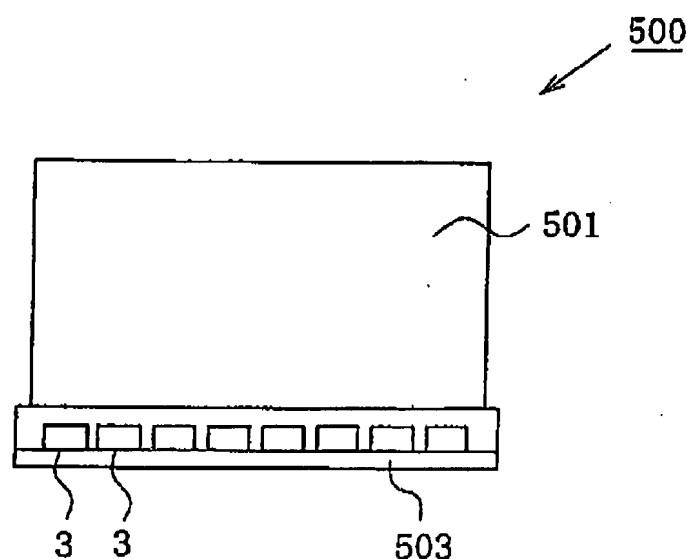
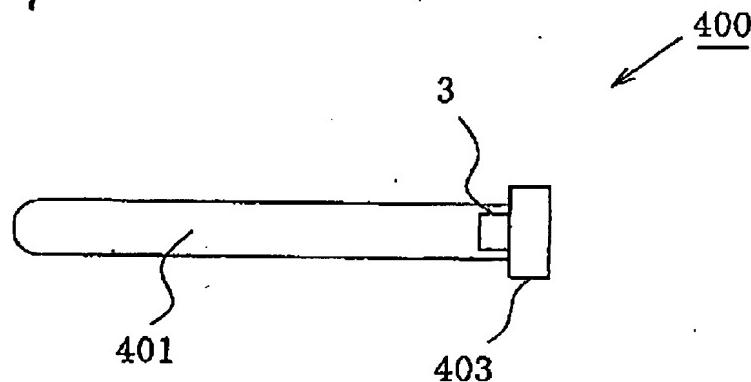
-图9-

Fig. 9



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特願平11-249350 頁: 10/ 12図1-01

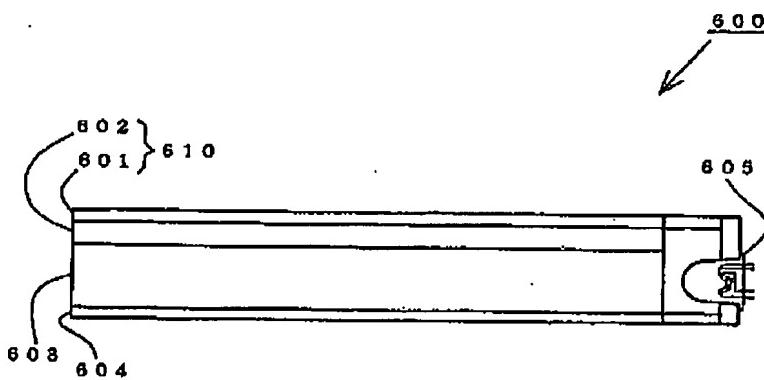
Fig. 10



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{図11}

Fig. 11



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〔図12〕

Fig. 12

